C-4.8 Illustrate the uses of electrochemistry (including electrolytic cells, voltaic cells, and the production of metals from ore by electrolysis). (additional content/depth)

Revised Taxonomy Level 2.2-B Exemplify (illustrate) conceptual knowledge

Students did not address this concept in physical science

It is essential for students to

- Identify, balance and explain simple oxidation-reduction chemical reactions, for example

  $CuSO_4 + Mg \rightarrow MgSO_4 + Cu$

  - Assign oxidation numbers to all elements in the reaction

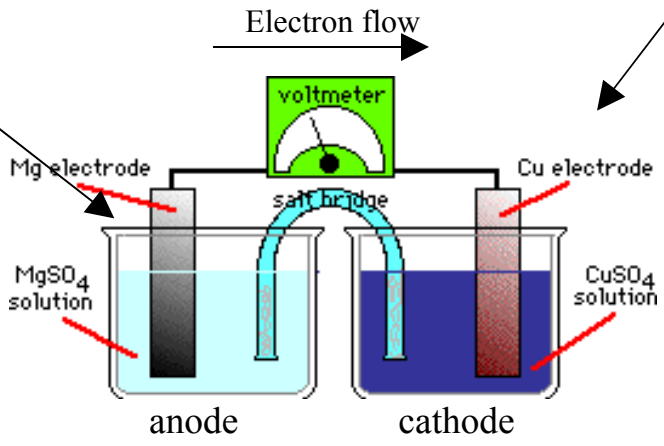
    $CuSO_4 + Mg \rightarrow MgSO_4 + Cu$

    Cu +2 Cu 0
    O -2 O -2
    S +6 S +6
    Mg 0 Mg +2
  - Understand that copper went from +2 to 0, it became more negative, so it gained electrons.
    - Copper is reduced.
  - Understand that magnesium went from 0 to +2, it became more positive, so it lost electrons.
    - Magnesium was oxidized.
  - Write the half reactions for simple oxidation-reduction reactions:
    - Reduction: $Cu^{+2} + 2e^- \text{----> } Cu^0$
      Oxidation: $Mg^0 \text{----> } Mg^{+2} + 2e^-$
  - Understand terms which are used to describe voltaic cells
    - A voltaic cell is an electrochemical cell in which the redox reaction occurs spontaneously and produces electrical energy.
    - The electrode is a conductor used to establish electrical contact with a nonmetallic part of a circuit (such as the electrolytes)
    - The anode is the electrode where oxidation takes place.
    - The cathode is the electrode where reduction takes place.
    - The salt bridge (or porous barrier) allows the reaction to continue because it
      - allows anions ($S0_4^{-2}$ from the $CuSO_4$ solution) to move toward the anode to replace the negatively charged electrons that are moving away during oxidation.
      - allows cations (Mg^{+2} from the Mg SO_4 solution) to move toward the cathode as to balance the negative charge resulting from reduction.
  - Diagram, label and describe the operation of a voltaic cell.

Example of a Voltaic Cell

Mg loses electrons at the Mg electrode. The electrons travel through the external wire to the Cu electrode.

Electrons, which have traveled through the external wire from the Mg electrode, enter the Cu electrode.



The Mg^{+2} ions that are formed when Mg atoms lose electrons enter the $MgSO_4$ solution.

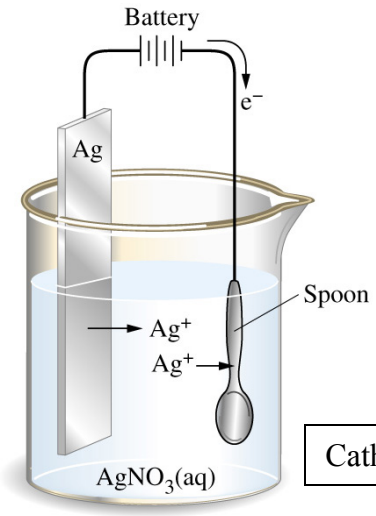
Cu^{+2} ions from the solution gain electrons which have traveled through the external wire, forming Cu metal which plates out on the Cu electrode.

- The reaction in this voltaic cell requires that 2 electrons are transferred from the Mg to the Cu.

- Use standard reduction potentials to calculate voltage of standard voltaic cells
- Understand that an electrolytic cell is one in which electrical energy is required to produce a redox reaction and bring about a chemical change in an electrochemical cell.
- Diagram, label and describe the operation of an electrolysis cell for electroplating (an example of an electrolytic cell

Electrolysis cell for electroplating

$Ag \rightarrow Ag^+ + e^-$
Metallic silver atoms are oxidized as electrons are attracted to the battery. They enter the solution as ions.



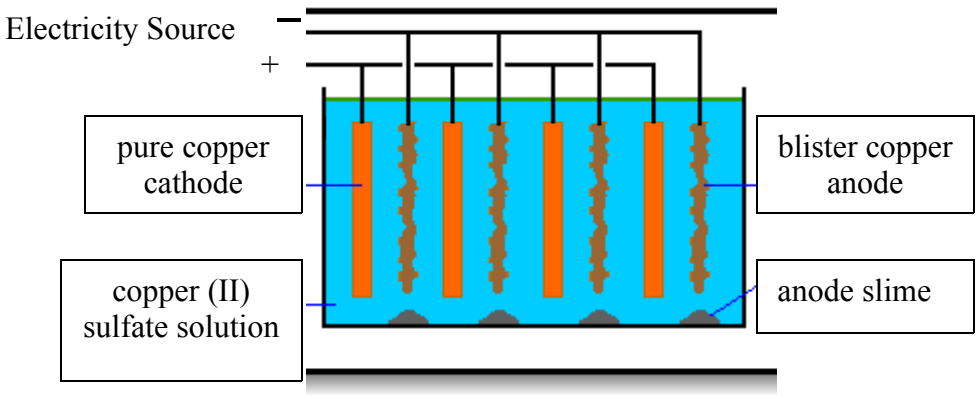
$Ag^+ + e^- \rightarrow Ag$
Silver ions are reduced by receiving electrons from the battery. Silver metal plates out on the spoon

Anode

Cathod

❖ Diagram, label and describe the production of metals from ore by electrolysis

Electro-refining of copper



- When copper is first obtained by reduction of its ores, it is cast as impure slabs or ingots, called blister copper.
- Blister copper is used for anodes
- Copper (II) sulfate is used as electrolyte.
- Initially, the cathodes consist of thin sheets of pure copper.
- During electrolysis, Cu metal in the blister copper receives electrons from the source of electricity and is reduced to Cu^{+2}. The Cu^{+2} ions pass into solution from the anodes.
  - Impurities in the anode, normally silver, gold and platinum are left behind. The impurities, which are collectively called anode slime, sink to the bottom of the cell.
  - The anode reaction is
    - $Cu_{(s)} \rightarrow Cu^{+2}_{(aq)} + 2e^-$
- At the cathode, copper (II) ions combine with electrons which are (from the source of electricity) forming Cu metal. The pure copper sheet becomes coated with an increasingly thick layer of very pure copper:
  - The cathode reaction is
    - $Cu^{+2}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$

Assessment

The verb exemplify (illustrate) means to find a specific example or illustration of a concept or principle, therefore the major focus of assessment will be for students to give examples that show that they understand the functioning of electrolytic cells, voltaic cells, and the production of metals from ore by electrolysis. Conceptual knowledge requires that students understand the interrelationships among the basic elements within a larger structure that enable them to function together. In this case, that students understand how each part of the various cells function to produce the desired condition.